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Recent studies indicate that seamounts can be sites of enriched biological activity with enhanced biomass of pelagic and benthic organisms relative to the surrounding water. We undertook a study to examine the interaction of micronekton/nekton and benthopelagic animals/epibenthic megafauna over a deep oceanic seamount, Fieberling Guyot, located in the eastern North Pacific. We monitored the number and movements of acoustically detectable targets within the bottom 100 m of the water column over the summit using a vertically-profiling acoustic array developed for this study. A large multiple opening-closing net system (10 m²) and free-vehicle baited traps were used to collect the pelagic fauna for identification, sizing and gut content analysis. A total of 26 acoustic targets were detected, dispersed non-randomly with a skewed distribution between 65 and 85 m above bottom. Temporal distribution of targets was random but revealed higher numbers in the morning than in the evening. The micronekton/nekton consisted of 114 species which were gravimetrically dominated by fish, especially the macrourid, *Malacocephalus laevis*. Four species of benthopelagic animals/epibenthic megafauna were collected including a new macrourid species, *Nezumia n.sp.*. There are no strong trends in the diel distribution of the micronekton/nekton and the limited data on acoustic targets shows a random temporal distribution. Alternative explanations of trophic coupling over Fieberling Guyot are discussed.

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TITLE: Coupling of pelagic and benthic communities over a seamount in the eastern North Pacific

INVESTIGATOR: K.L. Smith

INTRODUCTION

Recent studies indicate that seamounts can be sites of enriched biological activity with enhanced biomass of pelagic and benthic organisms relative to the surrounding waters (Boehlert and Genin, 1987; Boehlert, 1988). This enhanced biomass is believed related to the physical effect of the seamount on current flow and the subsequent generation of internal waves, local upwelling or possibly Taylor caps (e.g. Roden, 1987; Brink, 1989).

Abundance and biomass of plankton and nekton are often reported to be higher over seamounts (e.g. Zaika and Kovalev, 1984; Boehlert and Seki, 1984; Boehlert, 1988). Similarly, benthic megafauna are denser in the areas of enhanced current flow associated with the summit-slope break (Genin et al., 1986). These areas of high benthic biomass are also believed to be directly related to food supply. Diel vertically migrating zooplankton trapped over shallow banks during the day become prey to demersal and epibenthic animals (Isaacs and Schwartzlose, 1965; Genin et al., 1989) thus providing active trophic coupling between pelagic and benthic communities.

Based on these observations, we undertook a study to examine the interaction of micronekton/nekton and benthopelagic animals/epibenthic megafauna over a deep oceanic seamount, Fieberling Guyot, as part of a large interdisciplinary study of this topographic feature and its impact on current flow and biological processes. Our study was designed to address two hypotheses. 1) There is a diel periodicity in the distribution of micronekton/nekton within the bottom 100 m of the water column over the summit of Fieberling Guyot. 2) There is trophic exchange between micronekton/nekton and benthopelagic animals/epibenthic megafauna over the summit of Fieberling Guyot.

AREA OF INVESTIGATION:

Fieberling Guyot is a large submerged volcano rising above the surrounding sea floor at 4300 m to within 438 m of the surface in the eastern North Pacific. Fieberling is located ca. 992 km west of San Diego and is the westernmost seamount in a hotspot chain which extends northwest from Guadalupe Island off Baja California (Lonsdale, 1991). The summit of this seamount has a central area of bare rock reaching a pinnacle, a remnant of the volcano's magma conduit, rising to within 438 m of the sea surface. This exposed rock of the central area is surrounded by sediment, principally scoured cobbles in the east and volcanic and white foraminiferal sand in the west and north. Much of the sand surface is rippled by oscillating bottom currents which reach speeds up to 45 cm s^{-1} , measured at 10 m above the summit.

METHODS

To address the hypotheses concerning the trophic coupling between diel vertically-migrating animals and the benthopelagic animals/epibenthic megafauna associated with the seamount summit, we monitored the number and movements of acoustically detectible targets within the bottom 100 m of the water column over the summit using a vertically-profiling acoustic array developed for this study. Trawls and free-vehicle baited traps were used to collect the pelagic fauna for identification, sizing and gut content analysis while the discrete depth samples from the trawl in combination with the acoustic target

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data were used to estimate abundance and biomass of these animals during the peak periods of assumed migration, morning and evening. Demersal and epibenthic megafauna were also collected with the trawl and baited traps for identification and gut content analysis.

A. Acoustic detection/movements:

We developed a vertically-profiling acoustic array to monitor the movements of pelagic animals in the bottom 100 m of the water column over the Fieberling summit plain. This down-looking acoustic array was developed with the following characteristics: 1) insonify a large vertical volume of water to insure monitoring of rare events but with narrow sampling cells to detect target movements and avoid ambiguity from multiple targets in the same cell per unit of time, 2) measure the backscatter strength of individual acoustic targets (animals), and 3) operate for periods up to 6 months with large data storage capacity and low power requirements.

We built a rectangular transducer array with four primary sections to provide split-beam capabilities to resolve quadrant as well as vertical movement of individual targets. The configuration of the transducer array was determined using sonar simulation programs based on the expected animal target strengths under ambient noise and reverberation conditions. This four-section transducer is mounted in a down-looking orientation on a rigid frame using the basic electronic system we previously developed for a horizontal-profiling array (Smith et al., 1989). The instrument is configured as a free vehicle to allow positioning at a selected depth above the sea floor to maximize the insonified volume while optimizing the probability of having a single target in any of the 20-cm depth cells of the 4-transducer fields. A timed release is attached immediately above but outside the insonified field with a connecting nylon line (acoustically transparent) to the disposable ballast. The depth-cell length for all deployments was set at 20-cm intervals to sample from 0 - 100 m altitude with the returns above 100 m altitude gated out to reduce data accumulation. This programmable feature disables the receivers for a selected time (distance) after the transmit pulse: the programmed number of depth cells (500) are then sampled.

The two vertically-profiling acoustic arrays were deployed 11 times on 3 cruises during the one year field study of Fieberling Guyot. Each array deployment was configured similarly, with the VPAA moored at 62 to 98 m above the summit on a taught nylon line (Samson, double-braid, 1.27 cm diam) anchored by disposable ballast (181 kg) attached to a tandem timed release. The mooring above the VPAA consisted of a linear flotation package [8 glass spheres (Benthos), each with 25.4 kg positive buoyancy] suspended 100 m above on nylon line (Samson, double-braid, 1.91 cm diam) and a spar buoy with locating transmitter, strobe and flag. These deployments were made in areas of the summit where the topography relief was gradual and where they would not interfere with long-term current meter moorings (requiring 1 nautical mile radius clearance) and trawling operations by other investigators of this large interdisciplinary study.

The ping sequence on each deployment was organized into groups of four, with 5-s inter-ping intervals and an inter-group interval of 10 min. Pulse length was set at 0.56 ms. The threshold for signal storage was set just above the system noise on all but three deployments, which served as controls to evaluate target detection without thresholding. The sampling period ranged from 11 to 1083 h for the 11 deployments.

Acoustic data were processed on a Sun 3/60 computer, and the magnitudes of the returns were plotted as a function of time and distance from the array (Smith et al., 1989). Targets were differentiated on the magnitude plots based on a set of peaks spanning at least three consecutive pings in a sequence.

These potential targets were then corrected for spreading loss, source level, system sensitivity and angular elevation to produce final target strengths (Smith et al., 1989). Mean target strengths were calculated from corrected magnitude values over the detection sequence of pings.

B. Species composition:

The micronekton/nekton in the bottom 200 m of the water column over the summit of Fieberling Guyot were sampled with a trawl system and free-vehicle baited traps. A large opening-closing trawl system (10 m² mouth opening with 6 nets; MOCNESS; Wiebe et al., 1985) was used to sample between the summit and 157 m above during two cruises. The main body of each net is constructed of 4 mm circular mesh while the cod end is 505 μ m mesh. This trawl system was towed from a single conductor cable at a speed of 3.7 km h⁻¹. Shipboard signals from the underwater trawl via the conductor cable provided digital readouts of temperature, depth, conductivity, net frame angle, flow and time. The flowmeter failed to function properly on one cruise (May 1991) and the volume sampled by each net was estimated from net frame angle, flow and time during the (September 1990) cruise when the flow meter was calibrated and installed properly prior to sampling.

We conducted discrete depth sampling between 0500 to 0930 (5 trawls) and between 1700 and 2200, to address our hypothesis of a diel coupling between micronekton/nekton and benthopelagic animals/epibenthic megafauna. A total of ten trawls were made across the eastern portion of Fieberling summit during the May and September cruises in 1991, however the trawling planned for September 1990 failed because of equipment problems. Five of the trawls followed a tear-drop pattern, beginning the transect on the southern border of the summit and then executing a Williamson turn over the northern flank to finish discrete sampling over the summit on a southeasterly course. The remaining five trawls were made along straight northerly transects on a single pass over the summit plain. This trawling effort yielded 21 0.5-h samples over the summit in May 1991 and 10 0.5-h samples in September 1991. Every effort was made to maintain the trawl within 100 m altitude over the summit plain. However, two of the nets sampled benthic fauna while 6 others briefly exceeded the 100 m altitude. Since the altimeter failed to work during all the trawls, we estimated the trawl altitude from the difference between the depth readout from the trawl and the water depth determined every 2 minutes from the ship's precision depth recorder. Any net sampling which had a mean altitude exceeding 75 m or was taken at a mean water depth >575 m was excluded from our study.

Samples were removed from the cod ends of each net and the animals preserved in 5% seawater-buffered formalin for later analysis in the laboratory. Animals from each sample taken over the summit were sorted and identified by appropriate specialists. Samples from nets which were not open during trawling were used as controls to determine contaminants. Contaminants were largely gelatinous macrozooplankton and small copepods which are not considered as micronekton/nekton in this study.

Baited minnow traps were attached to free-vehicle mooring lines (Baldwin and Smith, 1987) at depths up to 200 m above the summit plain in October 1990 and May 1991. Plastic minnow traps (dimensions needed, length, diam, diam of opening) were suspended at 17 altitudes up to 200 m above bottom (2,5,10,20,30,40,50,60,70,80,90,100,120,140,160,180,200 mab) on two deployments in October 1990 and 1 deployment in May 1991 over the summit plain. These traps were baited with approximately 150 g of jack mackerel (*Trachurus symmetricus*) enclosed in fiberglass screen bags (1.5 mm² mesh) to prevent its consumption and set for two-day periods.

A large cuboidal fish trap (1.8 m³ volume) with two inverted conical openings (10 cm diam) was

deployed on a free-vehicle mooring independent of the minnow traps four times in October 1990 and once in May 1991 at depths ranging from <1 m to 53 m above bottom. This fish trap was baited on each deployment with three *T. symmetricus* tied to the inside compartment of the trap and set for periods of up to two days. On recovery, animals collected in the baited traps were measured and then frozen at -20°C for later identification, weighing and gut content analysis in the laboratory.

C. Abundance:

The number of micronekton per unit volume of water sampled was estimated from the VPAA data and trawl data. The useful volume of water insonified by each VPAA was dependent on the altitude of each deployment and ranged from 1900 to 7474 m³. These calculations were based on a 5° beam angle and the distance to the sea floor as estimated from the acoustic return. Strong reverberation from the transmitted pulse within 10 m of the array prevented target discrimination in this volume which was subtracted from the total to give a useful sampling volume. In accordance with Smith et al (1992), we have assumed that each ping group represents a discrete, non-overlapping sample of the insonified volume, since there was no evidence of recurrent targets between ping groups. We have identified targets from recurrent returns from at least three of the four pings per group.

Abundance of micronekton collected in the trawls were estimated from the volume of water sampled during each net tow over the summit of Fieberling Guyot, as calculated from the net mouth area, net angle and flowmeter reading (Wiebe et al., 1985).

D. Biomass:

The biomass of the micronekton was estimated from the acoustic array and trawl data. *In situ* acoustic target strengths were interpreted using either field-measured target strengths from individuals of known size belonging to the dominant micronekton species over Fieberling summit or previous laboratory and field measurements of similar species from other areas (e.g. Smith et al., 1992; Wiebe et al., 1990). Frozen specimens of micronekton (grenadiers) were thawed, measured, weighed and then suspended from a monofilament harness in the insonified field of the VPAA in a shallow water bay at ca. 2° C off the South Orkney Islands in September 1992. Target strength measurements were made as a function of distance and attitude with respect to the array. Copper spheres (23 mm dia. TS = -40.4 dB; 60 mm dia. w/ TS = -33.6 dB) were used as reference targets to convert the detected echoes to TS estimates. Target strength values were then calculated using:

$$TS_{\text{animal}} = 20 \log V_{\text{animal}}/V_{\text{sphere}} + TS_{\text{sphere}}$$

where V_{animal} and V_{sphere} are the echo voltages for an animal and copper sphere, respectively.

Mean TS values were regressed against animal length: a regression of length as a function of wet weight was also generated for the grenadiers. Using such regressions generated either in the field or from the literature, and the tentative identifications based on size, a measured target strength could then be converted to wet weight. Given an estimated weight for each target, total biomass of acoustic targets per unit volume of water was calculated.

Biomass of the micronekton collected in the trawl samples was estimated based on the wet weight of specimens, measured after 1 month to 2 years preservation, and the volume of water sampled for each successful tow (see above).

RESULTS

We arbitrarily divided the communities occupying the near-bottom and benthic habitats over the summit of Fieberling Guyot into the micronekton/nekton which occupy the water column and the benthopelagic animals/epibenthic megafauna which occupy the summit surface and the water column immediately above it.

Micronekton/nekton:

A total of 26 targets were recorded moving through the insonified field of the VPAA's during the four successful deployments over a cumulative sampling period of 84 hours in October 1990. Acoustic targets were detected between 35 and 90 m above the bottom, but no acoustic targets were detected in proximity (< 35 mab) to the summit plain. The vertical distribution of targets during the longest monitoring period, 2-day deployment (Sta. 42), were dispersed non-randomly and showed a skewed distribution toward higher altitudes with the largest concentration between 65 and 85 mab (Fig. 1). Two deployments of the VPAA closer to the summit plain (62 and 69 mab) revealed targets between 35 and 55 mab. The temporal distribution of acoustic targets during the 2-day deployment (Sta. 42) was random but revealed higher numbers in the morning than in the evening hours with a pronounced hiatus in target presence during the afternoon (1200 - 1600) and evening (1600 - 2000) (Fig. 1). Acoustic targets detected on the two shorter deployments were present from 2200 until 0300. However, these short deployments did not sample a complete day, especially the evening period which biases the sampling. Targets appear concentrated at altitudes between 10 and 20 m below the VPAA (Fig. 1) and we cannot discount the influence of the VPAA on the spatial distribution of the acoustic targets (animals), however, the temporal variation in target presence does not support this premise. If we discount any bias in sampling and the limited sample size, there is a distinct vertical separation of acoustic targets between the zone above 65 m and the zone at 35 to 55 mab.

The micronekton/nekton over the summit of Fieberling Guyot is composed of fish (68 species), cephalopods (11 species), decapods (11 species), euphausiids (21 species), mysids (3 species) for a total of 114 species over the two sampling periods, May and September. Also included with this fauna is the large copepod, *Gaussia princeps*, which is a common prey item found in the guts of grenadiers. Fish comprised 76% of the total number and 95% of the biomass of micronekton/nekton collected in the trawl. There were ten dominant species of micronekton/nekton which included six species of fish and four species of crustaceans. The fish species included, the sternoptychid *Argyropelecus affinis*, the myctophid *Ceratoscopelus townsendi*, the gonostomatids *Cyclothone acclinidens*, *Cyclothone signata*, and *Danaphos oculatus*, and the macrourid *Malacocephalus laevis*. The dominant crustaceans included the decapods, *Gennadas propinquus* and *Sergestes similis*, the euphausiid *Euphausia gibboides* and the mysid *Boreomysis californica*. The macrourid was gravimetrically dominant, contributing 75% of the total biomass.

Benthopelagic animals/epibenthic megafauna:

Three species of benthopelagic fish were collected in the baited traps within 3 m of the summit surface, the cyclostome *Eptatretus deani*, the elasmobranch *Etmopterus sp.*, and a new species of macrourid *Nezumia n.sp.*. None of these species were collected in the baited traps at higher altitudes up to 200 mab. or in the MOCNESS trawl samples. Similarly, none of the species of micronekton or nekton collected in the MOCNESS trawl were captured in the baited traps. One species of epibenthic megafauna, the brachyuran *Lithodes couesi*, was collected in the baited traps which were moored at < 1 mab.

DISCUSSION

Our study was designed to address two hypotheses. 1) There is a diel periodicity in the distribution of micronekton/nekton within the bottom 100 m of the water column over the summit of Fieberling Guyot. 2) There is trophic exchange between micronekton/nekton and benthopelagic animals/epibenthic megafauna over the summit of Fieberling Guyot. There are no strong trends in the diel distribution of the micronekton/nekton over Fieberling Guyot. The limited data on acoustic target distribution shows a random distribution with time and all of these targets are above 30 mab. We suspect the primary trophic coupling between the pelagic and benthic communities is through small particulate matter which serves as food for the extensive suspension-feeding benthic animals (sessile) on Fieberling summit. These sessile populations in turn support the mobile epibenthic megafauna and benthopelagic animals. A direct connection between the micronekton/nekton and the benthic community is not apparent in a preliminary analysis of these results.

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1. Smith, K.L., Jr., R.S. Kaufmann, R.J. Baldwin and R.C. Glatts. Coupling of pelagic and benthic communities over a seamount in the eastern North Pacific. (in preparation).
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Figure legend

Fig. 1. Twenty six acoustic targets (animals) detected on four deployments (Stas. 35, 38, 39, 42) of the vertically-profiling acoustic array in October 1990 as a function of distance above bottom and time of day over the summit of Fieberling Guyot. The moored distance above bottom for each acoustic array deployment is shown along with the time of sunrise and sunset. (Target designations: \square - Sta. 35, + - Sta. 38, X - Sta. 42; no targets were detected at Sta. 39).

